

What is claimed is:

1. A projection display system, comprising:

a light-recycling illumination system, wherein said light-recycling illumination system further comprises:

a light source for generating light, wherein said light source is at least one light-emitting diode having a reflecting layer, wherein the total light-emitting area of said light source is area A_S and wherein said light source has a maximum intrinsic source luminance and;

a light-recycling envelope, wherein said light-recycling envelope encloses said light source and wherein said light-recycling envelope reflects and recycles a portion of said light generated by said light source back to said reflecting layer; and

a light output aperture, wherein said light output aperture is located in a surface of said light-recycling envelope, wherein the area of said light output aperture is area A_O , wherein said area A_O is less than said area A_S , wherein said light source and said light-recycling envelope direct at least a fraction of said light out of said light-recycling envelope through said light output aperture and wherein said fraction of said light exits said light output aperture as uncollimated light having a maximum exiting luminance;

a light-collimating means, wherein said light-collimating means has an input surface that is adjacent to said light output aperture that accepts said uncollimated light, wherein said light-collimating means partially collimates said uncollimated light and wherein said light-collimating means has an output surface through which the partially collimated light is transmitted; and

an imaging light modulator, wherein said imaging light modulator is located in the optical path of said partially collimated light, and wherein said imaging light modulator spatially modulates said partially collimated light to form an image.

2. A projection display system as in claim 1, further comprising a reflective polarizer, wherein said reflective polarizer is located in the optical path of said partially collimated light and is located adjacent to said output surface of said light-collimating means, wherein said reflective polarizer reflects a first polarization state of said partially collimated light and wherein said reflective polarizer transmits a second polarization state of said partially collimated light.
3. A projection display system as in claim 1, wherein said maximum exiting luminance is greater than said maximum intrinsic source luminance.
4. A projection display system as in claim 3, further comprising a projection lens, wherein said projection lens is located in the optical path in a position after said imaging light modulator and wherein said projection lens magnifies said image formed by said imaging light modulator.
5. A projection display system as in claim 4, wherein said light-collimating means is chosen from the group consisting of a convex lens, a tapered light guide and a compound parabolic reflector.
6. A projection display system as in claim 5, wherein said imaging light modulator is chosen from the group consisting of a liquid crystal display device, a liquid-crystal-on-silicon device and a digital light processor device.
7. A projection display system as in claim 6, wherein said light source is a plurality of light-emitting diodes.
8. A projection display system as in claim 7, wherein said light source emits red light, green light and blue light.

9. A projection display system as in claim 8, wherein said light source comprises at least one light-emitting diode that emits ultraviolet light and wherein said light source further comprises a wavelength conversion layer that converts said ultraviolet light into said red light or said green light or said blue light.
10. A projection display system as in claim 8, wherein said light-recycling envelope is filled or partially filled with a transparent material having an effective refractive index greater than 1.60.
11. A projection display system as in claim 8, wherein said light source also emits a fourth color.
12. A projection display system as in claim 11, wherein said fourth color is chosen from the group consisting of white, yellow, cyan and magenta.
13. A projection display system as in claim 8, further comprising a control unit, wherein said control unit manages the timing sequence for the emission of said red light, said green light and said blue light by a color sequential means.
14. A projection display system as in claim 13, wherein said light-recycling illumination system emits red light and wherein said projection display system further comprises a second light-recycling illumination system that emits green light and a third light-recycling illumination system that emits blue light.
15. A projection display system as in claim 14, wherein said second light-recycling illumination system also emits yellow light.
16. A projection display system as in claim 14, wherein said third light-recycling illumination system also emits cyan light.
17. A projection display system as in claim 14, wherein said projection display system further comprises a color combining means.

18. A projection display system as in claim 17, wherein said color combining means is chosen from the group of a trichroic prism and an x-cube prism.
19. A projection display system as in claim 18, wherein said projection display system further comprises a second imaging light modulator and a third imaging light modulator.

20. A color sequential method of forming a full-color projection display image comprising the steps of:

dividing the time period for each frame of said full-color projection display image into at least a first sub-frame, a second sub-frame after said first sub-frame, and a third sub-frame after said second sub-frame;

during said first sub-frame, addressing all pixels of an imaging light modulator to set the transmission of said imaging light modulator for light of a first color, emitting said light of first color from a first light source that has a first reflecting layer, recycling a portion of said light of a first color back to said first reflecting layer to increase the effective brightness of said first light source, partially collimating a fraction of said light of a first color, directing the partially collimated said light of a first color to said imaging light modulator and spatially modulating said partially collimated said light of a first color to form a first image;

during said second sub-frame, addressing all said pixels of said imaging light modulator to set said transmission of said imaging light modulator for light of a second color, emitting said light of a second color from a second light source that has a second reflecting layer, recycling a portion of said light of a second color back to said second reflecting layer to increase the effective brightness of said second light source, partially collimating a fraction of said light of a second color, directing the partially collimated said light of a second color to said imaging light modulator and spatially modulating said partially collimated said light of a second color to form a second image; and

during said third sub-frame, addressing all said pixels of said imaging light modulator to set said transmission of said imaging light modulator for light of a third color, emitting said light of a third color from a third light source that has a third reflecting layer, recycling a portion of said light of a third color back to said third reflecting layer to increase the effective brightness of said third light source, partially collimating a fraction of said light of a third color, directing the partially collimated said light of a third color to said imaging light modulator and spatially modulating said partially collimated said light of a third color to form a third image.

21. A method as in claim 20, wherein said step of emitting said light of first color from a first light source is done with red light from a red light-emitting diode, said step of emitting said light of second color from a second light source is done with green light from a green light-emitting diode and said step of emitting said light of third color from a third light source is done with blue light from a blue light-emitting diode.

22. A method as in claim 21, further comprising:

emitting said green light at different green wavelengths from a plurality of different green light-emitting diodes in order to increase the color gamut of said full-color projection display image.

23. A method as in claim 21, further comprising:

emitting said red light, said green light and said blue light in random order in said first sub-frame, said second sub-frame and said third sub-frame.

24. A method as in claim 21, further comprising:

dividing the time period for each said frame into a fourth sub-frame after said third sub-frame and, during said fourth sub-frame, addressing all said pixels of said imaging light modulator to set said transmission of said imaging light modulator for light of a fourth color, emitting said light of a fourth color from a fourth light source that has a fourth reflecting layer, recycling a portion of said light of a fourth color back to said fourth reflecting layer to increase the effective brightness of said fourth light source, partially collimating said light of a fourth color, directing the partially collimated said light of a fourth color to said imaging light modulator and spatially modulating said partially collimated said light of a fourth color to form a fourth image.

25. A method as in claim 24, further comprising:

emitting said light of a fourth color by simultaneously emitting said red light, said green light and said blue light in order to produce white light.

26. A method as in claim 24, further comprising:

emitting said fourth color by simultaneously emitting said red light and said green light in order to produce yellow light.

27. A method as in claim 24, further comprising:

emitting said fourth color by simultaneously emitting said green light and said blue light in order to produce cyan light.

28. A method as in claim 24, further comprising:

emitting said fourth color by simultaneously emitting said red light and said blue light in order to produce magenta light.

29. A method as in claim 24, further comprising:

emitting said fourth color by emitting yellow light from a yellow light-emitting diode in order to increase the color gamut of the full-color image.

30. A method as in claim 24, further comprising:

emitting said fourth color by emitting cyan light from a cyan light-emitting diode in order to increase the color gamut of the full-color image.

31. A method as in claim 21, further comprising:

modifying the output brightness of said full-color projection display image by changing each of the red light output from said first light source, the green light output from said second light source and the blue light output from said third light source by the same numerical factor.

32. A method as in claim 21, further comprising:

modifying the output brightness of said full-color projection display image by changing each of the red light emitting time, the green light emitting time and the blue light emitting time by the same numerical factor.

33. A method as in claim 21, further comprising:

modifying the color temperature of said full-color projection display image by changing the ratio of the red light output to the green light output to the blue light output.

34. A method as in claim 21, further comprising:

modifying the color temperature of said full-color projection display image by changing the ratio of the red light emitting time to the green light emitting time to said blue light emitting time.